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AN INTEGRATED DATABASE ARCHITECTURE FOR SYSTEMS STUDIES IN UNDERWATER ACOUSTICS

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AN INTEGRATED DATABASE ARCHITECTURE FOR SYSTEMS STUDIES IN UNDERWATER ACOUSTICS

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SUMMARY (U)

An overview of the development of an Underwater Acoustics Database for use in systems studies applications is given. The database is managed by the locally developed Graphical Database Management System (GDBMS). This general purpose database management system has been designed to meet the needs of scientists working with oceanographic data. The important features of the system include the flexibility to handle data in a variety of formats, minimum redundancy storage space, automatic scaling and presentation of data from dissimilar sources (in user specified formats) upon retrieval, and the simple keyword driven operation designed for non-programmer users. Unusual features include the provision for graphical input and output of multi-dimensional data and interfaces to other user computer programs. Examples of several data tables or 'relations' using the GDBMS methods are given. Reference to how the database can be accessed by the Passive Array Sonar Prediction (PASP) code which provides signal excess predictions is also included.

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1. INTRODUCTION

1.1 Background

Maritime Systems Division of Weapons Systems Research Laboratory is responsible for research and development activities to improve passive sonar systems. This work includes assessment of the performance of present and future sonobuoys, and research and development activities on towed hydrophone arrays for naval vessels. These studies require both theoretical and experimental work to be undertaken to investigate the current performance of existing systems and to assess the potential of either modifications to current systems or entirely new concepts. Eventually both theoretical and experimental results of individual aspects of these investigations have to be reconciled to provide total systems performance evaluations.

The representations of data associated with separate aspects of a total system frequently have a variety of forms and different dimensionalities. For example, propagation loss for a number of different scenarios may be tabular or plotted against range while the detection threshold may be a single number.

A database approach is considered the best way of managing the large quantity of data required for systems studies applications and for ensuring the accessibility of data to a number of users who may not necessarily be programming specialists. The term database is used here in the sense of a structured collection of data of some particular type and which is managed by a software system referred to as the Database Management System (DBMS). A database comprises a number of 'relations' which are 2-dimensional data tables.

1.2 The Graphical Database Management System (GDBMS)

Commercial database management systems (DBMS) were examined and found to be lacking in fundamental ways, so an appropriate Graphical Database Management System (GDBMS) was developed by one of the authors (Keays) to serve Maritime Systems Division's requirements. A number of specific relations have been created using the GDBMS for underwater systems studies.

GDBMS uses a relational database approach whereby relations may be manipulated individually (as in the data acquisition or modelling and verification stages) or 'joined' and interfaced to user programs for advanced systems studies. The purpose of this report is to give an overview of GDBMS and the design concepts, method of operation and examples of relations running under GDBMS.

2. THE ROLE OF THE DATABASE

2.1 Historical development

The acquisition, storage and management of large amounts of data always requires effort and encounters problems. Until recently the storage medium was usually paper and when the volume of data became large the need for searches and quick access became difficult to satisfy. With the advent of mainframe computers of significant power centralised filing systems for large quantities of data (usually of an accounting or inventory nature) were developed. The development of databases followed, with bibliographic databases finding ready acceptance with libraries and their users. The

advent of significant computing power and digital storage capacity for relatively low cost is generating increasing interest in more general purpose databases.

We are interested in using mainly numeric data of environmental, oceanographic or geophysical origin. The importance of efficient retrieval of this data is obvious, but achieving this in practice is becoming increasingly difficult using traditional methods. Particularly in the oceanographic sciences, "it is infrequently that the data generator (the measurer or reporter) is also the end user (the one who applies these data in calculations, or in new experimental design...)"(ref.1). This is a natural consequence of the scale of resources needed and reflected in the growing costs to perform environmental measurements in this field. The paucity of data, and the difficulties (or often impossibility) of replicating experiments lead to concern with the observation that "especially for interdisciplinary purposes, data can be considered lost if they are not available in reliable, retrievable form"(ref.1).

An examination of the way in which this data is normally used, revealed that mere access to data only solved part of the problem - experimental data is required for some purpose, usually comparison with other data or a model, and interpretation as to its physical significance. The central role of the interpretative function in science is admirably brought out in a recent survey of numeric databases(ref.1).

They(ref.1) concluded that manipulation of numeric data is fundamental to the methods of scientific enquiry. The transfer of data between experiments, evaluation, conclusions and dissemination is vital to the whole process. Despite the acknowledged importance of the development of efficient data transfer mechanisms, "it is often considered the least glamorous part of our total scientific research program, and therefore nearly always displays severe symptoms of neglect"(ref.1). It was clear during the early stages of this database system, that to fully exploit the capabilities of a computerised retrieval system, the operating system should have significant additional capabilities compared to the simple bibliographic retrieval systems which have been available up to now. In recognition of these ideas, it became one of the aims of this activity to develop a computer-based aid which would significantly increase the productivity of scientists and engineers working on research and development of underwater detection systems.

2.2 Features required in a working scientific database

As noted in discussions below, the acceptance of pioneering attempts to computerise the task of retrieval of oceanographic data, has been varied, and differences in effectiveness suggest that the method of implementation of such a system can be quite important. Factors which were addressed in the development of the present system are listed below, and are discussed in greater detail in later sections.

2.2.1 Data storage

The first requirement of such a system is the capacity to reliably store the data required. Related topics included the variety of data formats and the amount and type of associated data used to identify or index each element. (An element here may be multi-dimensional, eg the full set of propagation loss readings at various frequencies and ranges at a particular site.) Efficient storage of data without data loss is highly desirable.

2.2.2 Data search

In a workable system it should be possible to automatically locate one or a set of elements either by index, or by selected attributes (eg all data south of a certain latitude and after a certain date).

2.2.3 Data retrieval and presentation

This was an area which previously caused considerable difficulty in the interpretive data assessment task when using paper storage media. In practice, data were often measured at different frequencies and, when recorded graphically, plotted on different scales. As it is frequently desirable to present complex data graphically and ready for interpretation, it was considered that a 'working database' should be able to present data graphically, and overlay data from any source on the user selected output format. When this was done the tasks of immediate user interpretation or subsequent processing (ie averaging a subset of the data) would be possible. A related problem in a multi-user environment is to be able to present data on different output devices. The data should also be adequately labelled to aid the user.

2.2.4 Data manipulation

Here the intention was to aid interpretation by comparison, accumulation of statistics to obtain macro-data, and other arithmetic 'joining' operations, eg to display the difference between model predictions and experimental results. For studies, it is also desirable to be able to interpolate between values of the independent variables, particularly for model outputs where behaviour is known.

As will be explained later the process of scientific model building relies on successive evaluation of the data and model predictions. It was considered essential that model predictions should be able to be readily inserted in the database, and that software performing operations (typically either on verified macro-data or model outputs) on the data should be able to access the database at run time.

2.2.5 Database management

This heading covers a range of features, the most important being to allow insertion, correction and deletion of data and attributes, the maintenance of data with integrity (ensuring that subsequent additions cannot corrupt previously entered data) and transfer of data and attributes to other programs or databases. If the database management structure has sufficient flexibility then it should be possible to use it for a range of subjects having numeric data of similar dimensionality.

With data from a range of sources - experimental, models, or unknown original, it is essential that the validity and/or accuracy of the data be recorded with the data so that confidence levels in its use can be intimated to a new user accessing it. This requires assessment of the data by a knowledgeable person preferably at the time of entry, and that some sort of validity flag or index be permanently stored with the data.

2.2.6 User friendliness

The establishment of a DBMS to be used by a range of specialists (but not specialists in computer science) demands that it be 'user friendly'. This is a reflection of the historical observation "DBMS documentation is notorious for being hard to follow, and practically impossible to

understand"(ref.2). In effect the aim is to ensure that a novice can operate the system without the need for special advice or the requirement to learn a complicated new language. This effect is normally achieved by the use of a 'menu-driven' software or a simplified special command language. Either approach can work without recourse to manuals only if an adequate level of prompts is supplied and if on-screen help can be called up at any time.

A second highly desirable simplification for non-programmer users is to minimise the number of key-strokes required in an interactive session. It is assumed here that for working analysis, the user needs to look at and operate upon the elements being retrieved from the database in real time, and not with delays as in batch mode. As any flexible system will provide a wide range of options to the user, this implies that default options are desirable for standard operations, and that consideration be given to storing 'user profiles' for users who regularly operate in non standard modes.

2.3 Existing underwater acoustics databases and related computer models

Databases or related computer packages for underwater acoustics applications exist at a number of locations outside Australia(ref.3,4,5,6). Their designs and configurations depend upon the expected users, who could be research scientists developing models, systems designers investigating new concepts or military personnel wishing to predict the "detection range for today" for specific targets using current systems. Consequently different sets of options need to be provided by a database system to cover these user types. They can be classified in terms of the following three basic variants: Research, Systems Design and Application Models.

2.3.1 Research models

These can be characterised as having the following form:

(1) Many options

(2) Results of intermediate calculations available for debugging and checking

(3) Include as much physics as possible

(4) Minimal mathematical approximation

(5) Complex environmental input needed

(6) No automatic database for reference

(7) No management of software

(8) Usually require a mainframe computer

(9) Execution time relatively unimportant

(10) Specific topics have specialised algorithms

(11) Outputs include simple graphics.

2.3.2 Systems design models

These can be characterised as having the following form:

(1) Many options but usually defaults available

(2) Less diagnostics compared to the research model

(3) The physics is simplified to various models

(4) Minimal mathematical approximation

(5) Standard environmental inputs used

(6) Part access to database for input

(7) Software managed loosely

(8) Usually require a mainframe computer

(9) Execution time relatively unimportant

(10) Basic models are brought together

(11) Graphics used extensively.

2.3.3 Applications models

These can be characterised as having the following form:

(1) Limited options if any

(2) No diagnostics (other than for operator guidance)

(3) Many physical assumptions

(4) Many mathematical approximations

(5) Environmental inputs for position and data from database

(6) Use measured data if available

(7) Software controlled

(8) Can use mainframe or desktop computers

(9) Fast execution required (possibly at the expense of accuracy)

(10) Important factors may be combined in simple forms

(11) Simple clear graphics and scalar readouts (eg, range of the day prediction).

During studies being undertaken at WSRL on passive sonar array systems, it was realised that the outputs of various research models would need to be combined with environmental data (which exists or will be collected in the future) to provide a systems design model. However, limited staff and resources led to constraints in the development of this model. It was also realised that the WSRL databases and their GDBMS software could be made available for use as RAAF and RAN applications models.

2.4 Overseas approaches to the problem

Prior to and during the development of underwater acoustic databases at WSRL, the methods adopted at Naval Ocean Research and Development Activity (NORDA)(ref.3,4), Supreme Allied Command Atlantic Research Center (SACLANTCENTER)(ref.5) and Naval Underwater Systems Center (NUSC) were considered(ref.6). The NORDA and Fleet Numerical Oceanography Center (FNOC) approach requires the whole ocean environment tc be mapped with respect to all the relevant parameters. Using these data the system constantly recalculates propagation loss and ambient noise to obtain signal excess and probability of detection. This method, the Automated Signal Excess Prediction System (ASEPS), requires extensive databases, computer execution time and confidence that various intermediate calculations give meaningful outputs. The propagation loss input to ASEPS is calculated using one model. This approach precludes the use of different models for different frequency ranges, or environments, or the use of real data if available. Similarly, ambient noise is calculated and one cannot choose to use real data.

The Generic Sonar Model(ref.6) operates in a similar manner, ie continuous recalculation on a mainframe computer. Its strongest feature is its ability to easily use various propagation models with the same input data. Its fundamental weakness, however, is its limitation to ray tracing at high frequency in deep water (ie not useable at low frequency in shallow water), poor ambient noise description and lack of environmental knowledge. The systems user must provide all the appropriate environmental data for each calculation.

2.5 WSRL approach

The alternative approach developed here has some similarity to that used at SACLANTCENTER(ref.5). The results of experiments and theoretical calculations using ray tracing (FACT9H, RAYMODE82), the parabolic equation method (IFD and split step), normal modes (SNAP) and the Fast Field Program (SAFARI) are stored in a separate database. The input for these calculations can also be stored for use by the acoustician but are not required by the system designer. In this approach both experimental and theoretical data can be used in the prediction of system performance, without the need for repeated recalculation. The ambient noise calculation model can call upon the propagation loss database for the appropriate data and the final noise results can also be stored in an ambient noise database along with measured data. Because the measurements are stored, the comparison of theory with experiment is much more efficient because the calculated outputs are be automatically in the same format. Thus the system designer accesses data with the acoustician's "seal of approval". A further advantage of the WSRL method is that whole databases can readily be transported to different hardware, eg simulators and micro-computers(ref.7). Thus the results of extensive and sophisticated calculations can be utilised in applications models for the RAAF and RAN.

2.6 DBMS's in general - commercial DBMS

Two DBMS's already available on the DSTO Salisbury central computer are IMS and SAS. Some brief comments about their suitability to our applications follows. IMS was one of the first large DBMS available. IMS, an IBM product, provides a flexible but complex hierarchical DBMS primarily for business and accounting types of applications. It is too complex for untrained scientific specialists, especially since its base language is COBOL. These comments also apply to the other CODASYL DBMS's. IMS also has questionable efficiency when confronted with data files of the size that would be required for say, range and frequency dependent propagation

loss data (ie 3 dimensional) at hundreds of sites and with a multiplicity of source and receiver depth combinations. Indeed the lack of an efficient means of representation of multidimensional numerical data appeared to be a fundamental stumbling block for all conventional DBMS's. SAS (Statistical Analysis Systems) came closer to our requirements in terms of its numerical and graphics facilities, but its data management abilities are only rudimentary (although they could be programmed using SAS as a core).

On the other hand, relational DBMS's are a newer development compared to hierarchical systems (such as IMS), and have more attractive capabilities.

However, commercially available relational DBMS's, and indeed research systems, still did not possess the numerical capabilities required by WSRL(ref.11).

3. THE DEVELOPMENT OF GDBMS

GDBMS was developed by one of the authors (Keays) as a relational DBMS to fulfil the specific needs outlined above. Additionally, the following advantages became apparent as system development proceeded.

(1) GDBMS is general purpose DBMS specially suited to scientific use. Without the special numerical capabilities GDBMS (as defined in reference 13) is a fully relational DBMS as defined in reference 11 with all the theoretical advantages that entails(ref.12). The addition of a multi-dimensional numerical attribute domain, while lacking theoretical integration to the relational model, provides a facility of great power and wide applicability.

(2) The Pascal code for GDBMS is concise and obviously accessible. This provides the advantage over commercial systems that modifications and enhancements are quickly and readily implemented. The data file formats are well defined and are necessarily supported by new software versions. This also tends to maintain a stable user interface.

(3) The different requirements of Research Systems application models are well met by GDBMS. As a simple but powerful interface between application software and the database it allows both acoustic modelling and operational systems to be well supported.

(4) The use of GDBMS obviates much redundant software development by virtue of its arithmetic, graphics and data retrieval facilities and its comprehensive external interface. Availability of the source code is also useful in this respect.

(5) Software development based on GDBMS is cheaper as no external licensing is required, especially for multiple installations as required for operational systems.

(6) Local software development and the use of Pascal made porting GDBMS to the IBM PC possible (see Section 3.5).

3.1 Relational databases

A relation is a two dimensional table of entries, with columns representing attributes of a data record of 'tuple' (ie fields of a record), and extending downwards as new records are added as shown schematically in figure 1. This tabular organisation is much simpler conceptually than the

hierarchical database (consisting of an arbitrarily complex graph structure). This is especially important for non-programmers' ability to use a DBMS.

Projection: Selects all the data from tuples in a relation (ie particular database) but includes only the data in specified columns (ie for stipulated attributes).

Restriction: Selects a subset of tuples which meet specified conditions (eg if selected attribute values fall within specified ranges).

Join: Combine tuples from two relations to form a third relation whose attributes are the set union of the attributes of the original relations, with the restriction that the tuples are only joined if specified common attributes have the same values in the original tuples. (See reference 12 for examples of the usefulness of this.)

The conceptual simplicity of relational databases puts more onus on the DBMS to represent and manipulate the data in an efficient and flexible way. The theory of relational databases is well developed (but still an active field of research(ref.12)). It is widely accepted that relational databases provide many advantages over hierarchial and network architectures by virtue of their regular algebra and other theoretical considerations. However some implementations have had a reputation for inefficiency. This has not proven to be a problem with GDBMS.

3.2 Attribute types

GDBMS supports attribute types based on Pascal type concepts.

3.2.1 Character strings

These are common to all DBMS's.

3.2.2 Integers and real numbers

Most DBMS support these types. GDBMS implements them in numeric formats rather than BCD or ASCII, for efficiency.

3.2.3 Enumerated

Enumerated types (ie a finite number of named values) are a powerful feature of Pascal. Similarly they are used in GDBMS as the most natural way of representing many attributes. This type facilitates:

(1) Efficient multi-key hashing algorithms

(2) Natural queries using sets

(3) Efficient storage.

Enumerated type are rarely seen in commercial DBMS's.

3.2.4 Multi-dimensional

The multi-dimensional type is the key to the power of GDBMS in scientific and engineering applications. It allows the storage of n-dimensional arrays of scalar data where n is an arbitrary dimensionality (a vector function could be represented by a number of such attributes).

GDBMS provides graphical facilities for input and output of these data but they are not at present used for database searches.

Figures 2 and 3 are examples of graphical output of GDBMS.

3.3 Join

Join is a fundamental and powerful operation in relational DBMS's. Its application in GDBMS is described fully in reference 13. Briefly, it combines 2 or more relations to form a new one by operating on a kind of cartesian product of the relations. The facility is extremely useful when evaluating the sonar equation, for example, where each term in the equation is obtained from an appropriate relation. Deferring to the next section the topic of arithmetic operations on database elements, the important thing to note here is the facility of the join operation to create a new attribute list for the new signal excess relation (for example) by computing the appropriate union of attributes from the joined relations, eg the target type attribute from the target relation and the sea state attribute ambient noise relation both appear as attributes in the signal excess relation derived from them.

3.4 Arithmetic on multi-dimensional attributes

Complementary to the join operation is the ability to perform arithmetic operations on multi-dimensional attributes. This is fully defined in reference 13 but requires, inter alia, interpolation over the intersection of the domain of the functions represented by the multi-dimensional attributes in the terms of arithmetic expression.

In essence this is the facility to perform arithmetic operations (user specified in the high level language PASCAL) on one or more data values obtained from selected tuples in nominated relations. To avoid problems caused when comparing or operating on parameters sampled at different values of the (same) independent variable(s), automatic linear interpolation of the input data is available if the required values are spanned in the source tuples.

This facility allows the user to graph, eg Signal Excess vs range vs frequency by summing the terms stored in several relations or to compare two graphs of propagation loss by graphing the difference of two tuples in the propagation loss relation.

3.5 Mainframe vs PC

GDBMS was originally written for the DSTO IBM 370/3033 central computer but later ported to the IBM PC XT(ref.7). Currently, software development is done on the PC using the 'Turbo Pascal' system. Working code is then transferred to the mainframe.

This dual implementation offers the following advantages.

(1) The mainframe database may be accessed by anyone on the network (which has terminals at DSTO Salisbury and DSTO Sydney).

(2) Small databases on floppy disks may be carried between PC's.

(3) PC databases may be established by transferring a subset of one or more databases from the mainframe and the latter may be augmented by inputting data from a PC database. For example, the mainframe terminal

at DSTO Sydney lacks a graph digitiser facility but a digitiser may be purchased for a PC, the data entered on a floppy disk database and then loaded into the mainframe database.

(4) PC's will provide the basis for operational systems using either floppy disks or portable hard disks.

(5) PC's are relatively cheap and there is a wide variety of third party peripherals and software available.

(6) Software development by contractor is more competitive on the PC.

4. RELATIONS IN THE UNDERWATER ACOUSTICS DATABASE

Tables 1 to 6 contain listings of the definition files for relations currently in use. They are self-explanatory.

5. INTERFACE WITH A USER PROGRAM (PASP)

PASP is an acronym for Passive Sonar Prediction. This program(ref.10) was developed to compute predictions for the likely detection range to be expected from generic passive sonar systems. Several forms of output are available, including signal excess, equivalent detection range (for systems of specific gain) and probability of detection (assuming ideal or experimental transition curves).

The only specific sonar modelling performed within this software is concerned with the frequency dependent gain and detection thresholds for specific types of arrays and processors. In execution the program undertakes the computationally trivial task of evaluating the Sonar Equation. The usefulness of this program stems from the fact that in each run it evaluates the Sonar Equation for every standard frequency and range pair for which sufficient input data are available. The output data are thus three-dimensional, and the user has a choice of output devices and formats. The flexibility of this software is due in large part to the fact that it obtains the data needed for each run from the relevant relations. All the array and processor independent data are accessed from the relevant relations. At the present time there are relations for Ambient Noise, Self Noise, and Propagation Loss. The program accesses the relations at run time and for efficiency retrieves the entire requested attribute in one pass. In the case of propagation loss one attribute is a sequence of vectors describing propagation loss data at different frequencies. The actual frequencies found are not critical as, provided the desired run frequency being evaluated at any instant is within the span of the data from the database, the interface software will interpolate to the required frequency. The data are mapped similarly onto the range scale.

For convenience, the program is menu-driven, and displays results to the operator interactively. To reduce complexity to an acceptable level, the user must know the identity (address) of the records or 'tuples' to be called in each relation before running the program. The relevant addresses are entered into the menu before program execution. This is not considered a handicap, because in practice significant effort is always required in selecting, processing and validating data (the tasks which GDBMS was designed to facilitate) prior to using it as input to systems studies.

More detailed information on how to use the PASP program is available elsewhere(ref.10).

6. ADMINISTRATION AND VERIFICATION PROCEDURES

For a complex software system such as GDBMS and its individual databases it is essential that control over the input data and any software modifications are maintained. Consequently there are a number of documents that need to be available. These include:

(1) Functional description

(2) Program specification

(3) User's manual

(4) Data Validation - a set of administrative procedures and instructions to permit control over this data flow into, within and out of, the database.

Items 2 and 3 are being provided as part of the software development contract(ref.13).

7. DATA EXCHANGE

GDBMS provides the formats for data exchange either physically on magnetic media, or electronically.

7.1 Within Australia

Database exchange between elements of Maritime Systems Division and other DSTO Laboratories should become routine as the database grows.

Operational systems would rely on distribution of data from Australian Defence Force authorities, which have responsibility for collecting and analysing data, to the operational systems on ships or aircraft. Data transfer should also occur between Maritime Systems Division and these authorities.

7.2 International exchange

It is hoped that GDBMS will be made widely available, thus providing a medium of scientific data exchange internationally.

8. SUMMARY

This document describes the philosophy behind the development of GDBMS in WSRL. It identifies the functions required of a scientific database to handle oceanographic (or similar) data for both ocean acoustic, and systems studies modelling. Available commercial systems were found to have significant shortcomings. The functions of the new software, implemented in Maritime Systems Division to meet these requirements, are described. The advantages of the new software include efficiency, versatility, portability and its ability to handle, interpolate from and display multi-dimensional arrays of numerical data. The software is designed for use by scientists and other non-specialists in computing.

TABLE 1. ATTRIBUTE DEFINITIONS FOR THE PROPLOSS DATABASE

VARIABLE NAME	PASCAL TYPE	PERMITTED VALUES
'Experimental'	ENUMERATED	expermnt theory
'Low f b loss'	ENUMERATED	A B
'High f b loss'	ENUMERATED	low med high
'XBT Region'	ENUMERATED	TA TB TC TD TF AB AC AD AE AF AG JB BW KI HW1 HW2 HW3 HW4 GH GB BA TORRES TIMORC OR1 GA GC GD GF GG GJ GE
'P L Region'	ENUMERATED	North South
'Reliability'	ENUMERATED	unverif low med high
'Month'	ENUMERATED	Jan Feb March April May June July Aug Sep Oct Nov Dec
'Year'	INTEGER	1900 2050
'Comments'	CHARACTER 48	
'Latitude'	REAL	-90 90 'Degrees'
'Longitude'	REAL	-180 180 'Degrees'
'Water Depth'	REAL	0 6000 'Metres'
'Source Depth'	REAL	0 6000 'Metres'
'Rec Depth'	REAL	0 6000 'Metres'
'Prop Loss'	POINTER	'Frequency' 'Hz' 'Range' 'km' 'Propagation Loss' 'dB @ 1m'

TABLE 2. ATTRIBUTE DEFINITIONS FOR THE AMBNOIS DATABASE

VARIABLE NAME	PASCAL TYPE	PERMITTED VALUES
'Ship or Wind'	ENUMERATED	Ship Wind Both
'XBT Region'	ENUMERATED	TA TB TC TD TF AB AC AD AE AF AG JB BW KI HW1 HW2 HW3 HW4 GH GB BA TORRES TIMORC OR1 GA GC GD GF GG GJ GE
'P L Region'	ENUMERATED	North South
'Reliability'	ENUMERATED	unverif low med high
'Month'	ENUMERATED	Jan Feb March April May June July Aug Sep Oct Nov Dec
'Comments'	CHARACTER 48	
'Ship Type'	ENUMERATED	Fish Merchant Naval Other
'Ship Density'	ENUMERATED	Light L/Med Medium M/Heavy Heavy
'Year'	INTEGER	1900 2050
'Seastate'	INTEGER	0 9
'Wind Speed'	REAL	0 100 'Knots'
'Latitude'	REAL	-90 90 'Degrees'
'Longitude'	REAL	-180 180 'Degrees'
'Water Depth'	REAL	0 6000 'Metres'
'Duct Depth'	REAL	0 6000 'Metres'
'Rec Depth'	REAL	0 6000 'Metres'
'Ambient Noise'	POINTER	'Frequency' 'Hz' 'Noise' 'dB' re 1uPa**/Hz
'Expt/Theory'	ENUMERATED	Expermnt Theory

TABLE 3. ATTRIBUTE DEFINITIONS FOR THE SELFNOISE DATABASE

VARIABLE NAME	PASCAL TYPE	PERMITTED VALUES
'Expermental'	ENUMERATED	expermnt theory
'Country origin'	ENUMERATED	AUST US UK CAN NZ OTHER
'Wall material'	ENUMERATED	Rubber PVC PVC009 PVCH25 Other
'Tow mode'	ENUMERATED	Surface Subsurf Barossa Other
'Type of fill'	ENUMERATED	Solid Liquid B-fibre Other
'Comments'	CHARACTER 48	
'No hyds/grp'	INTEGER	0 50
'Hose diameter'	REAL	0 200 'mm'
'Fill density'	REAL	0 2000 'kgm/m3'
'Array length'	REAL	0 5000 'Metres'
'Water temper'	REAL	-50 50 'Celcius'
'Group length'	REAL	0 50 'Metres'
'Dist from end'	REAL	0 5000 'Metres'
'Self Noise'	POINTER	'Speed' 'Knots' 'Frequency' 'Hz' 'Self noise' 'dB re 1mPa**2/Hz'

TABLE 4. ATTRIBUTE DEFINITIONS FOR THE VERTNOIS DATABASE

VARIABLE NAME	PASCAL TYPE	PERMITTED VALUES
'Ship or Wind'	ENUMERATED	Ship Wind Both
'XBT Region'	ENUMERATED	TA TB TC TD TF AB AC AD AE AF AG JB BW KI
'P L Region'	ENUMERATED	North South
'Reliability'	ENUMERATED	unverif low med high
'Month'	ENUMERATED	Jan Feb March April May June July Aug Sep Oct Nov Dec
'Comments'	CHARACTER 48	
'Ship Type'	ENUMERATED	Fish Merchant Naval Other
'Ship Density'	ENUMERATED	Light L/Med Medium M/Heavy Heavy
'Theory or Expt'	ENUMERATED	Theory Experiment
'Year'	INTEGER	1900 2050
'Seastate'	INTEGER	0 9
'Wind Speed'	REAL	0 100 'Knots'
'Latitude'	REAL	-90 90 'Degrees'
'Longitude'	REAL	-180 180 'Degrees'
'Water Depth'	REAL	0 6000 'Metres'
'Duct Depth'	REAL	0 6000 'Metres'
'Rec Depth'	REAL	0 6000 'Metres'
'Vertical Noise'	POINTER	'Frequency' 'Hz' 'Elevation' 'Degrees' 'Vertical Noise' 'dB' re 1uPa**2/Hz

TABLE 5. ATTRIBUTE DEFINITIONS FOR THE SOUNDVP (SOUND VELOCITY PROFILE) DATABASE

VARIABLE NAME	PASCAL TYPE	PERMITTED VALUES
'Expt/Theory'	ENUMERATED	expermnt theory
'XBT Region'	ENUMERATED	TA TB TC TD TF AB AC AD AE AF AG JB BW KI HW1 HW2 HW3 HW4 GH GB BA TORRES TIMORC OR1 GA GC GD GF GG GJ GE
'Comments'	CHARACTER 48	
'Reliability'	ENUMERATED	unverif low med high
'Month'	ENUMERATED	Jan Feb March April May June July Aug Sep Oct Nov Dec
'Year'	INTEGER	1900 2050
'Latitude'	REAL	-90 90 'Degrees'
'Longitude'	REAL	-180 180 'Degrees'
'Water Depth'	REAL	0 6000 'Metres'
'Sound Speed'	POINTER	'Depth' 'Metres' 'Sound Speed' 'm/s'

TABLE 6. ATTRIBUTE DEFINITIONS FOR THE BLUG DATABASE

VARIABLE NAME	PASCAL TYPE	PERMITTED VALUES
'Reliability'	ENUMERATED	unverif low med high
'Comments'	CHARACTER 48	
'Region'	ENUMERATED	TA TC GH BB AB AF
'Province'	ENUMERATED	Abyssip Abyssih Contrise Contterr Fan
'Theory or Expt'	ENUMERATED	Theory Experiment
'Year'	INTEGER	1900 2050
'Latitude'	REAL	-90 90 'Degrees'
'Longitude'	REAL	-180 180 'Degrees'
'Water Depth'	REAL	0 6000 'Metres'
'Bottom Loss'	POINTER	'Frequency' 'Hz' 'Grazing angle' 'Degrees' 'Propagation Loss' 'dB'

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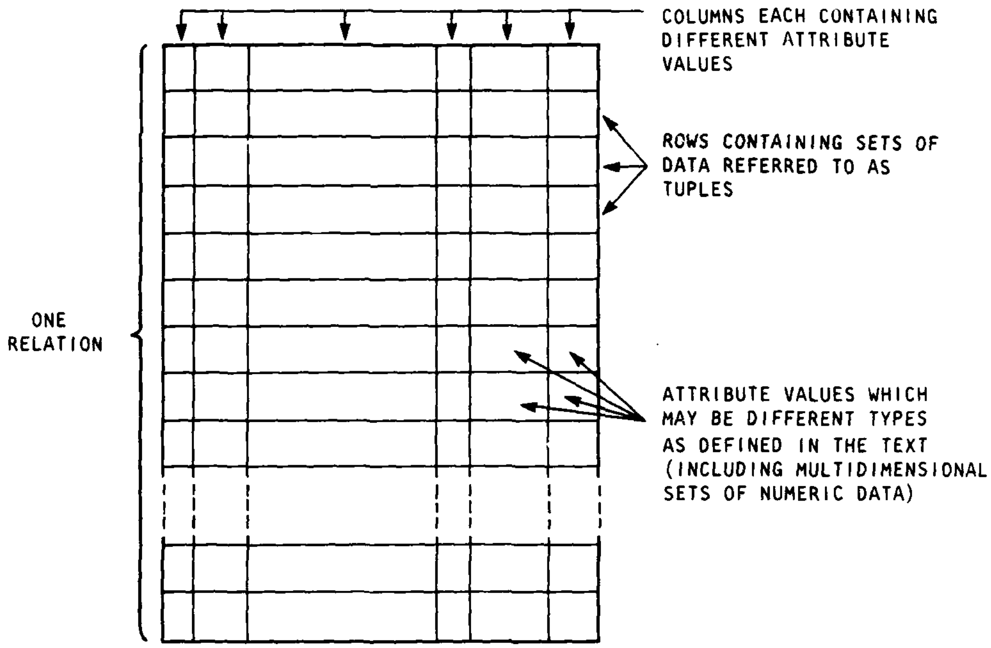

Figure 1. Schematic of a relation

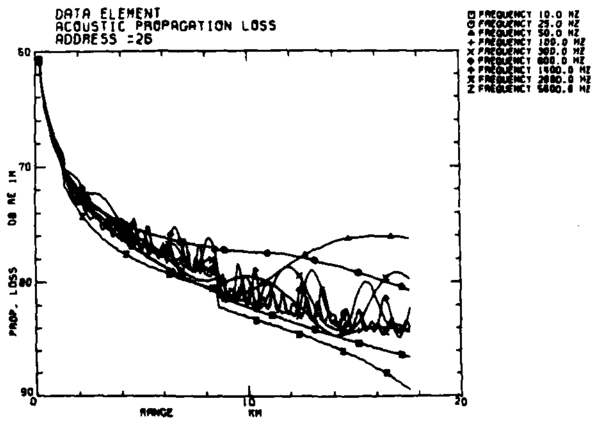

Figure 2. Example of data in one tuple in the GDBMS Propagation Loss Relation displayed using the line graph option

Figure 3. Example of data displayed with the three-dimensional colour plotting option in GDBMS

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17 SUMMARY OR ABSTRACT
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An overview of the development of an Underwater Acoustics Database for use in systems studies applications is given. The database is managed by the locally developed Graphical Database Management System (GDBMS). This general purpose database management system has been designed to meet the needs of scientists working with oceanographic data. The important features of the system include the flexibility to handle data in a variety of formats, minimum redundancy storage space, automatic scaling and presentation of data from dissimilar sources (in user specified formats) upon retrieval, and the simple keyword driven operation designed for non-programmer users. Unusual features include the provision for graphical input and output of multi-dimensional data and interfaces to other user computer programs. Examples of several data tables or 'relations' using the GDBMS methods are given. Reference to how the database can be accessed by the Passive Array Sonar Prediction (PASP) code which provides signal excess predictions is also included.

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